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14. ABSTRACT

An instrumentation facility for the evaluation for electro-optic and sensor protection materials has been implemented at the University of Washington. This facility is being used in the evaluation of materials of interest to defense and telecommunications industries and government laboratories including Air Force Research Laboratories. Preliminary results have shown that dendrimer materials are the materials of choice for electro-optic and sensor protection applications.

15. SUBJECT TERMS
Femtosecond spectroscopy, degenerate four wave mixing, electro-optic activity, dendrimers, phase-sensitive-detection, multi-wave mixing, electronic dynamics

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INSTRUMENTATION FACILITY FOR THE EVALUATION OF ELECTRO-OPTIC AND SENSOR PROTECTION MATERIALS
F49620-99-1-0220

Final Technical Report

Submitted to

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4/25/00
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REVIEW OF OBJECTIVES

The objective of this contract was to construct an instrumentation facility for the evaluation of electro-optic and sensor protection materials. This required construction of a femtosecond spectroscopic facility with the capability of frequency agility over visible and infrared wavelengths and of phase-sensitive-detection. The femtosecond spectrometer that has been implemented is described in the Journal of Physical Chemistry A, vol. 103, no. 14, pages 2290-2301 (1999). Instrumental capability for the accurate measurement of electro-optic coefficients is also an objective.

STATUS of EFFORT

All instrumentation proposed has been implemented and is currently being used to characterize material under consideration for electro-optic and sensor protection applications. After construction of the proposed facility, careful calibration was carried out over a period of several months to assure that reliable electro-optic coefficients and two photon absorption coefficients could be obtained with the new facility. Following calibration testing, the facility has been put to use in characterizing materials of interest to both industrial and government laboratories. In particular, dendrimer materials have been shown to yield record electro-optic and two-photon absorption coefficients.

PERSONNEL SUPPORTED

No personnel received financial support from this contract. The following individuals worked on assembling and utilizing the instrumentation:

Dr. Larry R. Dalton
Dr. Philip Reid
Mr. Brendon Carlson
Mr. Gregory Phelan
Mr. Daniel Casmir
Mr. Leonard Fifield

AFOSR F49620-99-1-0220 Publications

1. I. Liakatas, C. Cai, M. Bosch, M. Jager, Ch. Bosshard, P. Gunter, C. Zhang, and L. R. Dalton, Importance of Intermolecular Interactions on the Nonlinear Optical Properties of Poled Polymers, Appl. Phys. Lett., 76, 1368-70 (2000).
2. T. M. Londergan, C. Zhang, A. Ren, L. Dalton, Dendrimer Functionalized NLO Chromophores, Polym. Prepr., 41, 783-4 (2000).
3. L. R. Dalton, H. R. Fetterman, F. Wang, W. Steier, A. W. Harper, A. S. Ren, and J. Michael, Class of High Hyperpolarizability Organic Chromophores and Process for Synthesizing the Same, U.S. Patent 6,067,186 (May 23, 2000).
4. C. Wang, C. Zhang, P. Wang, P. Zhu, C. Ye, and L. R. Dalton, High Tg Donor-Embedded Polyimides for Second-Order Nonlinear Optical Applications, Polymer, 41, 2583-90 (2000).
5. D. Huang, C. Zhang, L. R. Dalton, and W. P. Weber, "Synthesis and Characterization of Main-Chain NLO Oligomers and Polymers That Contain 4-Dialkylamino-4'(alkyl-sulfonyl) azobenzene Chromophores," J. Polym. Sci. Part A: Polym. Chem., 38, 546-59 (2000).
6. D. Huang, C. Zhang, L. R. Dalton, and W. P. Weber, Second-Order NLO Property Study of Main-Chain Oligomers and Polymers, Polym. Prepr., 41, 330-40 (2000).
7. T. E. Hogen-Esch, J. Pan, M. Chen, L. R. Dalton, W. Warner, and M. He, Synthesis of Block Copolymers Containing a Main Chain Polymeric NLO Segment, Polym. Prepr., 41, 940-1 (2000).
8. J. Pan, T. E. Hogen-Esch, M. Chen, W. Warner, and L. R. Dalton, Hydrogen Bond-Mediated Self-Assembly of Block Copolymers Containing NLO Segments, Polym. Prepr., 41, 963-4 (2000).
9. J. Pan, M. Chen, W. Warner, M. He, L. Dalton, T. Hogen-Esch, Synthesis of Block Copolymers Containing a Main Chain Polymeric NLO Segment, Macromolecules, 33, 4673-81 (2000).
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11. C. Zhang, M. Lee, A. Winkleman, H. Northcroft, C. Lindsey, A. K. Y. Jen, T. Londergan, W. H. Steier, and L. R. Dalton, Realization of Polymeric Electro-Optic Modulators With Less Than One Volt Drive Voltage Requirement, Materials Research Society Symposium Proceedings, Vol. 598, Electrical, Optical and Magnetic Properties of Organic Solid State Materials (Materials Research Society, Pittsburgh, 2000) pp.BB4.2.1-12; also available in electronic format from the MRS website.
12. A. K. Y. Jen, H. Ma, X. Wu, J. Wu, and L. R. Dalton, High Performance Side-Chain Aromatic Polyquinones for Electro-Optic (E-O) Devices, Materials Research Society

Symposium Proceedings, Vol. 598, Electrical, Optical and Magnetic Properties of Organic Solid State Materials (Materials Research Society, Pittsburgh, 2000) pp. BB4.4.1-6; also available in electronic format from the MRS website.

13. H. Ma, B. Chen, L. R. Dalton, and A. K.-Y. Jen, Novel Perfluorocyclobutate-Containing Thermoset Polymers and Dendrimers in Electro-Optics, Proc. PMSE, 83, 165-6 (2000).
14. J. N. Woodford, C. H. Wang, C. Zhang, and L. R. Dalton, Measurement of the First Molecular Hyperpolarizability of Charge-Transfer Chromophores Using Hyper-Rayleigh Scattering at Multiple Infrared Wavelengths, Proc. PMSE, 83, 218 (2000).
15. G. Todorova, J. Chen, and L. R. Dalton, New NLO Chromophores Based on 2-Amino-1,1,2-Tricyano-1-Propene Acceptor, Proc. PMSE, 83, 256-7 (2000).
16. D. Huang, X. Jiang, G. D. Phelan, T. M. Londergan, A. K.-Y. Jen, and L. R. Dalton, Organic Electroluminescent Device Based on Phenanthrene Containing Europium Complex, Proc. PMSE, 83, 266-7 (2000).
17. L. R. Dalton, Design and Assembly of Nanostructured Electro-Optic Polymers, Proc. PMSE, 83, 554 (2000).
18. L. R. Dalton, Nonlinear Optical Polymeric Materials: From Chromophore Design to Commercial Applications, in Advances in Polymer Science (Springer-Verlag, Heidelberg, 2001) in press.
19. T. Londergan and L. R. Dalton, Control of Optical Properties Using Various Nanostructured Materials: Dendrimers, Phase-Separating Block Copolymers, and Polymer Microspheres, Mol. Cryst. Liq. Cryst., in press.
20. J. N. Woodford, C. H. Wang, C . Zhang, and L. R. Dalton, Resonant and Nonresonant Hyper-Rayleigh Scattering of Charge-Transfer Chromophores, Appl. Phys. Lett., submitted.
21. L. R. Dalton, B. Robinson, W. H. Steier, C. H. Zhang, and G. Todorova, Systematic Optimization of Polymeric Electro-Optic Materials, Proc. SPIE, 4114, in press (2000).
22. C. H. Zhang, G. Todorova, C. Wang, T. Londergan, and L. R. Dalton, Synthesis of New Second Order Nonlinear Optical Chromophores: Implementing Lessons Learned from Theory and Experiment, Proc. SPIE, 4114, in press (2000).
23. L. R. Dalton, Electrooptic Applications, in Encyclopedia of Polymer Science and Technology, (J. Kroschwitz, ed.) John Wiley & Sons, New York, 2000.
24. L. R. Dalton, B. H. Robinson, and W. H. Steier, Production of High Bandwidth Polymeric Electro-Optic Modulators with V_{π} Voltages of Less Than 1 Volt, Mol. Crys. Liq. Cryst.: Nonlin. Opt., in press (2000).
25. L. R. Dalton, Realization of Sub 1 Volt Polymeric EO Modulators Through Systematic Definition of Material Structure/Function Relationships, Synthetic Metals, in press (2000).

Awards of the Principal Investigator:

•2000 Distinguished Alumni Award of Michigan State University

•1996 Richard C. Tolman Award of the Southern California Section, American Chemical Society

•Paul C. Cross Lectureship, University of Washington, Seattle, WA (1996)

•NASA Lecturer, 54th Frontiers in Chemistry Lecture Series (1995), Case Western Reserve University

•The 1990 Univ. of Southern California Associates Award for Creativity in Research and Scholarship

•1986 Burlington Northern Foundation Faculty Achievement Award
•NIH Research Career Development Awards (Two Awards; 75-81)
•Camille and Henry Dreyfus Teacher-Scholar Award (75-77)
•Alfred P. Sloan Fellowship (74-77)

Total Number of Publications of the PI in the past twelve months: 59